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DEVELOPMENT AND EVALUATION OF SELF-INSTRUCTIONAL MATERIALS FOR UNDERACHIEVING AND OVERACHIEVING STUDENTS.

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AN EXPLORATION OF THE INTERACTION BETWEEN PROGRAMED TEACHING DEVICES AND INDIVIDUAL CHARACTERISTICS OF HIGH SCHOOL STUDENTS WAS UNDERTAKEN. THERE WERE FOUR PARTS -- PREPARATION OF MATERIALS ON GEOMETRY, THE ESTABLISHMENT OF CRITERION MEASURES, PRELIMINARY PILOT EXPERIMENTS, AND THE MAIN EXPERIMENT. THE MAIN EXPERIMENT WAS PERFORMED IN 27 CLASSES IN 3 HIGH SCHOOLS. THE VARIABLES TESTED WERE ACHIEVEMENT CHARACTERISTICS (OVER, NORMAL, AND UNDERACHIEVERS) OF APPROXIMATELY 250 STUDENTS, AND THE ROTE AND CONCEPTUAL FORMS OF THE PROGRAM. THE CONCLUSIONS WERE (1) THE DIMENSIONS FOR SPECIFYING THE LEARNING TASK, METHOD, AND STUDENT HAVE NOT BEEN IDENTIFIED, (2) A PERIOD OF INFORMAL HYPOTHESIS DEVELOPMENT SHOULD PRECEDE FORMAL EXPERIMENTS, AND (3) THE POTENTIAL ADVANTAGES OF PROGRAMED INSTRUCTION, AND PARTICULARLY OF HIGHLY RESPONSIVE PROGRAMED INSTRUCTION, ARE NOT EFFECTIVE AT THE SECONDARY SCHOOL LEVEL. ATTEMPTS TO KEEP METHODS WITHIN THE PROGRAMED INSTRUCTION FRAMEWORK HAVE IMPAIRED THE EFFECTIVENESS OF THE INSTRUCTION. FUTURE RESEARCH WAS SUGGESTED TO DETERMINE THE EFFECTIVE COMBINATION OF INSTRUCTIONAL TECHNIQUES AND METHODS FOR SPECIFIED TASKS AND FOR STUDENTS OF SPECIFIED CHARACTERISTICS. (RS)

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Harry Silberman John Coulson Evelyn Gunn Ralph Melaragno

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TECHNICAL MEMORANDUM

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Development and Evaluation of Self-Instructional Materials for Underachieving and Overachieving Students

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Other members of the SDC research staff also participated in this project. John Cogswell was a co-investigator on Pilot Study Number 2. Don Estavan wrote the computer programs for the SDC teaching machine which were used in the preparation of earlier versions of the instructional material.

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Development and Evaluation of Self-Instructional Materials for Underachieving and Overachieving Students

Harry Silberman, John Coulson
Evelyn Gunn, Ralph Melaragno

System Development Corporation

General Introduction

In the early development of teaching machines and programed instruction, attention was focused largely upon the design of the instructional devices or programed materials and upon the operational methods used in the application of these devices and materials. This initial emphasis on methodology and equipment is reflected not only in the promotional literature of companies manufacturing teaching machines, but also in the majority of the earlier experimental reports in this field published in educational and psychological journals.

The findings of early research on programed instruction have been of value in revealing some of the general capabilities and limitations of this method of instruction. In particular, this research has demonstrated the effectiveness of instructional materials that are written to lead the student systematically through a succession of learning goals, and that are iteratively revised and improved on the basis of student response data.

Recently, however, there has been a shift of research emphasis from the teaching devices and the auto-instructional methodology per se to an examination of the ways in which these factors may interact with student characteristics and with subject matter or task variables in determining student learning efficiency under programed instruction. The central question in programed instruction is not whether such instruction can produce learning behavior, nor what kind of programed instruction can produce most efficient learning. Rather, we ask what teaching machine designs or auto-instructional methods are most effective for a student having certain characteristics and for a certain type of subject matter and criterion task.* Such concern reflects both the growing maturity of research in programed instruction and our increasing recognition of the need to take account of individual differences in our educational theory and practice.

The project just completed represents an attempt to explore interactions between certain auto-instructional method variables and a group of student variables. The student variables were selected to sample both academic performance factors and personality factors.

Geometry was selected as the subject matter for research conducted in the project. Geometry represents an important subject in the secondary school curriculum, and is adaptable to being organized and taught in a variety of ways, thus making it a useful experimental vehicle.

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*Taking a still broader perspective we may ask what combination of teaching aids and methods will provide most effective instruction for various conditions of student and subject matter variables. Under certain conditions the optimal instructional system may include programed instruction, closed-circuit television lecture and textbooks--each applied where it can most effectively meet the learning needs of the student.

A secondary concern of the project was to use the capabilities of a highly flexible, computer-based instructional system to maximize the advantages gained by using student performance data for the revision of programed materials. By using the computer to give students some option in selecting their own paths through a basic "library" of instructional items, it was possible to gain useful information about which items and item sequences were most essential for the required student acquisition of subject matter. The resulting data could then be used to construct the final linear programs which were presented to students operating in their normal classroom environments. Thus the project provided an opportunity to evaluate the effectiveness of a computer-based system as a tool in the selection and ordering of programed materials.

OUTLINE OF THE PROJECT

The project was conducted in several phases, as outlined below:

1. A set of programed materials on plane geometry was prepared. These materials were revised on the basis of preliminary trials, and subportions of the total set were selected for subsequent experiments.
2. Criterion measures were prepared for use in subsequent experiments.
3. Several preliminary pilot experiments were conducted. These studies used a number of combinations and variations of the basic instructional program, and were designed to permit evaluation of the materials and of certain instructional techniques.
4. The main experiment was conducted.

The following portions of this report will describe the steps taken in the phases outlined above.

PREPARATION OF THE PROGRAM

Orientation meetings were conducted with teachers from Santa Monica, Culver City, and Lennox High Schools to describe the project and to seek solutions to a number of practical problems involved in the conduct of the study. Topics discussed at these meetings included the form of teacher assistance to be provided during the study, the question of whether homework should be assigned during the experimental period, time schedules, testing programs, and specifications of topics to be taught. A number of topics were chosen which are regularly taught in each of the schools during the second semester of plane geometry. These topics include seven theorems and selected portions of coordinate geometry (directed lines, projections, and distance formulas).

Six mathematics teachers were chosen as a writing team to assist in the preparation of the items. Members of the SDC staff worked intensively with the teachers on programing techniques. Each teacher was responsible for preparing two sequences of items, one written in rote fashion and the other written with conceptual emphasis. Teachers were urged not to bias their writing in favor of either method, inasmuch as their own students would be exposed to both forms.

The difference between rote and conceptual sequences is not extreme, since each sequence had to be self-sufficient and a reasonable approach to the subject. The distinctions between the two forms are: (a) in proving theorems, the rote sequences proceed step-by-step from beginning to end, while conceptual sequences may start from what has to be proved and work backwards, successively reducing the gap between what is to be proved and what is given; (b) rote sequences generally supply the student with needed information without stressing strategy of proof, while conceptual sequences contain more discussions of methods of attack; (c) rote sequences refer to specific figures and examples; conceptual items use generic references and more abstract examples (the number of examples used with both forms is approximately equivalent); and (d) the student is asked to supply missing steps more often in the conceptual material.

Geometry programs produced by a commercial program producer were offered to the teachers as guidelines for the preparation of materials. Teachers found these programs more constraining than helpful, however, and chose to develop their own ideas in writing items. Procedures used in preparing two forms of a linear programed text on geometry are described below.

The first draft of the program was completed on May 2, 1961. Items were edited by the SDC staff and the teachers were asked to review and edit each other's items. Ten high school students were given the revised draft of the programs and asked to describe any difficulties they experienced with the materials. These students were also given a sample of test questions which were written for the criterion test being developed. Data from these trials were used to remove ambiguities, fill gaps, eliminate redundancies and correct errors. Topics which were difficult for slower students were identified and remedial items were written to correct potential errors in these areas.

A branching structure incorporating the original and remedial items was then developed. The resulting programs were prepared for the SDC computer-based teaching machine (see Appendix A). These programs consisted of 760

35-mm slides and the punched paper tapes which controlled the computer. One half of the items were for the rote method and the other half for the conceptual method. Each half covered all of the topics in the program.

The teaching machine maintained a continuous record of several aspects of student performance, including cumulative error rate, specific answers given to individual items, and student self-evaluation. Based on these criteria, the machine selected as it proceeded through the lesson a sequence of instructional items appropriate to the performance of the student. The brighter student was given a minimum of material, while the slower student was given extra remedial material in areas where he was weak.

The items were presented in this branching fashion to students from University High School (Los Angeles) just prior to their entry into second semester geometry. Their responses to these items were analyzed and the more commonly occurring sequence patterns were incorporated in a linear sequence of items. These items were bound in the form of linear programed textbooks and sent to three judges who independently reviewed each topic and rated it on a rote-conceptual continuum. In every case, the rote version of a given topic was judged to be more rote than the conceptual version of the same topic.

These booklets were then used in three initial pilot studies to provide further testing of the items and also to obtain evidence on variables related to the main experiment. Several revisions were made of the two versions of the geometry programs following the pilot studies. The pilot studies were also used to evaluate a pool of test questions for use in the criterion test for the main experiment.

The revised booklets for the rote and conceptual versions of the program which were used in the main experiment contained 526 and 550 items respectively. The topics covered are designated in Appendix B.

PREPARATION OF THE CRITERION TEST

Test items from the pilot studies served as a pool for the development of the objective test which was used as a pretest and posttest for the main study. Very difficult items which were primarily indicative of aptitude rather than knowledge covered by the program were eliminated. Trivial questions were also omitted. The remaining items were classified in a two-way matrix by subject matter topic and by level of educational objective (factual, understanding, and application). Two items per theorem or major topic for each of the three levels were selected from the matrix, giving a total of 54 objective items. Three judges independently reviewed these items and classified them. Where at least one judge disagreed with the original classification, the item was revised or a new item written until agreement on item classification was obtained. The purpose of this procedure was to insure content validity of the test.

Appendix C contains the criterion test with key, the instructions to the judges who classified the test questions, and the resulting classification of the numbered test questions by level of behavioral objective and by topic.

Analysis of the criterion test items was concerned largely with the ability of the test to discriminate between students who had been trained with the geometry program and students who had not received the program. It was felt that this form of analysis was more appropriate to the evaluation of programed instruction than the traditional item analysis techniques based on differences among students who have received the training. In a programed lesson the object is to bring all students to a relatively uniform level of performance;

this restriction in the spread of scores among students who have used a programed lesson would naturally reduce any coefficients which are a function of variance among the test scores.

In the present study the initial form of the criterion test was taken by students who had been given the geometry program and by other students who had not. Comparison of the test item difficulty indices indicated that the test was able to discriminate between the two groups.

The mean difficulty index for the criterion test (ratio of number of students making errors on an item to total students taking the item) for a group of 55 students who were in the middle of a second semester geometry course but had not received the geometry program was .60. The mean difficulty index for a group of 54 students who had just completed first semester geometry and had been given the geometry program was .35. In general, students who had not received the program performed essentially at the chance level while students who had received the program answered at least half of the test questions correctly. The split-half reliability of the first draft of the criterion test on a classroom of students who had not received the program but had received a course in second semester geometry was .68.

The technique used for evaluation of criterion test items was in agreement with the suggestion by Hammock (1960) that test items should be selected on the basis of their ability to discriminate between students who have and students who have not received the training, rather than among students all of whom have received training.

PILOT STUDY #1 - AN ANALYSIS OF READING COMPREHENSION AND PROGRAMING METHODS USING A BIVARIATE COVARIANCE DESIGN

The main experiment of this project is concerned with the relative effectiveness of the two forms of the geometry program, rote and conceptual. However, a significant difference on the posttest performance of subjects taking the two programs might be attributed to a difference in reading difficulty of the two forms, rather than to the relative effectiveness of a rote vs conceptual approach to programing. For example, students with a high reading comprehension score might do better than students with low reading comprehension on the conceptual method but may not differ on the rote method merely because the conceptual material requires more reading comprehension. Consequently, the present pilot study was designed to determine whether or not the two forms differed in comprehension level thus biasing results on a posttest in favor of one form.

In most experiments where performance on programed material is evaluated, two measures are obtained: time to complete the items (training time) and errors on a posttest. Each dependent variable is usually analyzed separately. If one method is superior to another on the basis of error scores and the training times are equivalent, or if one method takes less time than the other and the scores are equivalent, unambiguous interpretation of results is possible. Generally, however, one method will be superior to another with respect to error scores but only at the expense of training time, making the results difficult to summarize. In this study we used the bivariate analysis of variance-covariance model in order to simultaneously consider the subjects' performance on both variables. Since one purpose of the study was to provide data for revision of the material, errors on training items rather than posttest items were considered.

Procedure

Twenty-two paid volunteer students from University High School were subjects of the experiment. They were randomly assigned to the two treatment groups which were designated rote and conceptual. Each student was given the Reading Comprehension section of the Cooperative Reading Tests on his first training day.

The total geometry program for each group consisted of 378 frames. These frames were divided into four sections, administered one section per day. Subjects were instructed to proceed through the material at their own rate--to work as seriously as they would in a classroom situation.

Program material was presented to each subject individually by a "teaching machine" consisting of a Bendix G-15 computer which controlled the presentation of slides by a large capacity random-access slide projector. The student responded by selecting an answer and typing an appropriate key on an IBM electric typewriter. The computer determined the correctness of the response and signaled a message which was automatically typed out by the IBM typewriter. Response messages indicated "Right," "Wrong," "Wrong, try again," or "Wrong, the correct answer is ________."

The program had a simple branching format; i.e., students were branched to remedial material when errors were made on individual test items or were branched to review items when errors accumulated over a number of test items. Time on each item was recorded and the computer printout provided a complete record of each student's progress through the material.

Results

Table 1 gives the unadjusted means and ranges of errors and time required to complete the program for the two treatment groups. A bivariate analysis of covariance model was used to analyze these results, with reading comprehension as the control variable.

The first hypothesis tested was that slopes of the regression lines of reading comprehension level on rote learning performance and on conceptual learning performance were the same. Results of the analysis yielded no significant difference in slope, and thus showed no evidence that reading comprehension might bias subsequent research with the geometry programs in favor of either treatment method.

The second hypothesis was that there would be no difference between performance on the rote and performance on the conceptual materials, after adjustment for reading comprehension scores. When time and errors were considered together, the rote method proved superior at the .05 level to the conceptual method.

A test of the criterion components, time and error, indicated that differences in number of training errors were responsible for the statistical difference in treatment method.

Table 1

Performance on Rote and Conceptual Forms of the Geometry Program

Group	Range of Training Time (Minutes)	Mean (Minutes)	Range of Errors	Mean
Rote	163 - 390	247	14 - 40	24.6
Conceptual	216 - 360	291	9 - 45	29.9

PILOT STUDY #2 - TEST ANXIETY AND PROGRAM DIFFICULTY

Previous work by Sarason and Palola (1960) has shown that low-anxiety subjects will learn best on a psychomotor task which is difficult enough to increase their anxiety, while high-anxiety subjects will learn best on the same task when it is made simple enough to reduce anxiety. Sarason and Palola further showed that the inclusion of instructions designed to induce anxiety benefited low-anxiety subjects and the inclusion of anxiety-reducing instructions benefited high-anxiety subjects.

The present study was designed to determine whether similar manipulations of the learning situation would provide results consistent with those of Sarason and Palola when continuous-discourse, self-instructional materials were used. The first hypothesis was that low-anxiety subjects would perform best on difficult material while high-anxiety subjects would perform best on easy material. The second hypothesis was that anxiety-provoking instructions would be beneficial to low-anxiety subjects and that anxiety-reducing instructions would be beneficial to high-anxiety subjects.

Method

Two self-instructional programs, covering the proofs of four theorems in plane geometry, were prepared. The Hard program consisted of only the items necessary to cover the theorems; the Easy program consisted of the same items plus additional items further explaining the most difficult portions.

Four anxiety-provoking statements were included in the Hard and Easy programs for half of the students. These statements, in general, said that performance on the program was directly related to the students' scholastic and vocational success. Four anxiety-reducing statements were also written and included in the programs for the other half of the students. These statements said that performance on the program bore no relation to scholastic and vocational success.

Students from two high schools who had the requisite mathematical backgrounds volunteered for the experiment and were administered a measure of test anxiety (Sarason, 1958). From the original sample of 116 subjects, the 24 showing the highest anxiety and the 24 showing the lowest anxiety were used in the study. The 48 subjects were randomly assigned, six in each of the eight treatment groups.

Subjects worked their way through the programs at their own rate of speed, in two group settings. Following the completion of the instructional materials, subjects were given a 40-question, multiple-choice test on geometry, with 10 questions on each theorem.

Results and Discussion

Table 2 contains the means and standard deviations for the eight treatments. Neither of the two hypotheses was supported. No significant differences between the Easy and Hard programs were found.

At least two possible explanations for the inability to demonstrate the predicted differences are available. One is that the dissimilarities between the Easy and Hard programs, and between the anxiety-reducing and anxiety-provoking statements, were too small to produce the anticipated effect.

Table 2

Performance Scores for Eight Treatment Combinations

		Easy Program		Hard Program	
		Provoking	Reducing	Provoking	Reducing
High Anxiety	M	18.14	20.00	21.14	21.71
	SD	5.24	6.61	5.46	4.40
Low Anxiety	M	24.43	22.57	20.57	20.43
	SD	3.37	7.84	2.26	4.61

The other is that Sarason's findings on psychomotor learning tasks are not relevant to verbal, continuous-discourse tasks. Further experimentation is necessary to more fully test the basic findings and/or the possible explanations for the results.

PILOT STUDY #3 - METHODS OF REPEATING ITEMS FOR REVIEW

In preparing a program, it is necessary to determine the amount of review or repetition of items which is desirable. Kormondy (1960) found no differences between programs with and without review items. Ferster (1961), using 61 lessons from the Skinner-Holland psychology program, compared a group that received a single trial through the program with a second group receiving a single trial and one repetition. No differences in learning were obtained. It appears that programs may have sufficient built-in redundancy so that it is unnecessary for the student to recycle through the program. In order to verify this possibility, a comparison was made among five methods of repeating review items for review purposes.

Method

Ninety paid volunteer high school students who were taking first-semester geometry at University High School were used in the study. These students were randomly assigned to five treatment groups. In Group 1, students received a programed sequence of four geometry theorems with no repetition. In Group 2, each item of each theorem was repeated immediately. Group 3 received all of the items in a theorem, and then received the entire theorem again before going to the next theorem. Group 4 received the entire program and then a repetition of the program. For Group 5, the delay between an item and its repetition was increased as the learner progressed through the program. For example, in the first theorem, each item was repeated immediately; in the second theorem, all the items were presented before the second theorem was repeated; in the remaining two theorems, all the items were presented before both theorems were repeated.

Programed booklets providing these treatment conditions were prepared and given to the students participating in the study. Immediately after the program was completed, a test was administered. Two weeks later, a retest was given on the possibility that differential effects of the treatment conditions, though not present immediately after training, might show up after a short interval of time had elapsed. The criterion test consisted of 32 objective application questions and 32 questions on statements and reasons for the proofs of the four theorems covered in the program.

Results

Table 3 gives the means for test, retest, and aptitude scores for the five treatment groups. Analysis of these data, adjusting for differences in aptitude, showed no significant differences among the five conditions on the immediate posttest and on the retention test.

Table 3

Test Performance for Repetition Treatments

Treatment Group	Mean Test Score	Mean Retention Score	Mean Aptitude Score
1	37.3	39.6	114.9
2	39.6	38.8	114.5
3	26.8	33.5	109.7
4	40.7	46.7	117.2
5	37.4	39.5	118.9

MAIN EXPERIMENT - EVALUATION OF ROTE AND CONCEPTUAL PROGRAMS FOR UNDERACHIEVING AND OVERACHIEVING GEOMETRY STUDENTS

The purpose of the main experiment was to determine the effectiveness of two forms of a geometry program (described on pages 5-7) with three kinds of students. The two independent variables were the achievement characteristics of the student (overachievers, normal achievers, and underachievers) and the form of the program (rote and conceptual).

It was hypothesized that a significant interaction would be obtained between the two variables. It was expected that with the rote form, overachievers would perform better than underachievers. On the conceptual form, no difference was expected between underachievers and overachievers. In other words, it was predicted that the conceptual program would eliminate motivational differences between the two groups.

Method

Subjects. The subjects were 258 students in second-semester geometry courses at Culver City High School, Lennox High School and Santa Monica High School. The California Test of Mental Maturity and the Seattle Geometry Test administered at the end of first-semester geometry were used to assign students to achievement groups. If a student's first-semester geometry achievement score exceeded the achievement score predicted by his aptitude score by at least one standard error of estimate, he was classified as an overachiever. If the achievement score predicted by the aptitude score of a subject exceeded his actual achievement score by at least one standard error of estimate, he was classified as an underachiever. Other students were classed as normal achievers. Further details on the methods and rationale of student classification are given in Appendix D.

Materials. The two geometry programs each covered the same seven theorems plus selected topics in coordinate geometry. The rote form proceeded in step-by-step fashion from the beginning to the end of each theorem, whereas the conceptual form started from what had to be proved and worked backwards, gradually reducing the gap between what was to be proved and what was given. The rote form supplied the student with steps in the theorem without stressing the strategy of the proof, while the conceptual form contained more discussion on method of attack. The student was also required to supply missing steps in the proofs more often in the conceptual form.

Four revisions were required in the development of the two programs. The two final versions of the program, consisting of approximately 550 items for each form, were assembled into 20 linear self-instructional booklets. Each booklet was designed to fill a 40-minute study period.

Procedure. The experiment was conducted during a three-week period in February. The criterion test was administered at the beginning and again at the end of this period. Students devoted each class period during the experiment to studying a programed booklet. If a student finished the workbook before the period was over, he was asked to fill the remaining time by reviewing the booklet. Students were not permitted to ask their teacher for any assistance. All students had been told that their performance would affect their class grade.

No homework assignments were given during the study. The regular geometry textbooks had been collected at the end of the first semester and were not distributed until the project was completed.

Further details on scheduling and on instructions to students and teachers are given in Appendix E.

Design. A 3 x 2 analysis-of-covariance design was used with aptitude and pretest scores as control variables. Thus, within each school six groups were formed: overachieving rote, overachieving conceptual, normal-achieving rote, normal-achieving conceptual, underachieving rote, and underachieving conceptual.

Results

A significant main effect difference was obtained among the achievement levels. The overachievers did significantly better than the normal achievers, and the normal achievers did significantly better than the underachievers. The hypothesis that there would be a significant interaction between the form of the program and achievement characteristics of the students was not confirmed. Table 4 gives means and standard deviations on dependent and control variables for the treatment groups. Table 5 shows intercorrelations among the tests, and correlations between test scores and student attitudes toward the programs.

While results of the total test scores for all schools provide no evidence for a preference of one version of the program over the other for different achievement levels, analysis of subtest scores for individual schools yielded some interesting differences. For each school seven covariance analyses were made using aptitude and pretest scores as control variables, and the following subtests as dependent variables: factual questions duplicating items in the program; "understanding" questions requiring some extrapolation from the program items; application questions covering novel situations; questions on the material covered in the first third of the program on the topic of similarity; questions

Table 4

Aptitude, Pretest, and Posttest Means for Treatment Groups*

		ROTE			CONCEPTUAL		
		Aptitude	Pretest	Posttest	Aptitude	Pretest	Posttest
Over-achievers	M	114.35	18.79	34.9	112.21	19.30	34.9
	SD	10.10	4.95	8.0	13.35	6.41	6.9
Normal-achievers	M	110.05	15.47	28.3	112.44	16.86	27.4
	SD	13.55	4.51	8.4	13.04	3.39	6.3
Under-achievers	M	114.07	14.26	25.0	113.84	15.21	25.1
	SD	11.79	3.70	6.4	12.47	4.06	6.3

*Total N = 258

Table 5

Correlation Coefficients

(N = 258)

	Pretest	Posttest	Attitude
Aptitude	.274*	.397*	-.098
Pretest		.511*	-.022
Posttest			.040

* $p < .001$

on the material covered in the middle third of the program on the topic of tangents and right triangles; questions on the last third of the program on selected coordinate geometry topics; and all the questions in the criterion test.

Tables 6, 7, 8, and 9 summarize the results of these analyses for each of the three schools and for all the schools combined. For School #3, a significant interaction was obtained when a subtest covering the last third of the program on topics in coordinate geometry was analyzed. The overachievers did better on the rote form of the program while the normal and underachievers did better on the conceptual form. In School #1, a significant interaction was obtained on the application questions which measured transfer of learning. Overachievers did better on the conceptual form while normal-achievers and underachievers did better on the rote form of the program. In School #2, a significant difference was obtained in favor of the rote method both on the application subtest and on questions covering the middle third of the program.

It is possible to speculate on why different results were obtained among the three schools but such conjecture must await future research for confirmation since no systematic data were collected on school characteristics in this study. Informal observations of the three schools may provide the reader with some hypotheses for explaining why students from the different schools tended to respond in characteristically different ways. School 1 and School 3 were located in a somewhat higher socio-economic area than School 2. The teachers in School 2 indicated a slight preference for the rote material during an early stage in its preparation. The coordinate geometry portion of the program was prepared by two teachers in School 3 who expressed some preference for the conceptual approach. School 3 is larger than School 1 and 2 and is perhaps somewhat more formal and less lenient in allowing low achievers in first semester geometry to move into the second semester course. If teacher attitude and socio-economic factors are related to differences in results, it is probably not a simple relationship since the obtained interactions were in different directions and on different subtests.

Analysis of an evaluation questionnaire (see Appendix F) which was filled out by the students after the experiment indicated that they liked the program about the same as their regular textbooks. As shown in Table 5, however, attitude toward the program was uncorrelated with aptitude, pretest and post-test scores. Some students enjoyed being able to check their answers without the risk of embarrassment. The teachers reported later that the students showed evidence of understanding the topics which were covered during the experiment and felt the study was a valuable experience for the students. Some students, however, lost interest during the third week and expressed concern about going on with their "regular" work. They missed being able to ask questions of the teacher, working at the board, and having social interaction in class. Some felt the program made learning too easy and provided no sense of having "learned something."

Discussion

In summary, this experiment seems to demonstrate that "once an overachiever, always an overachiever." The data emphasize that most of the variance of the

Table 6

F Tests for School 1*

	A Rote-Conceptual Variable	B Achievement Level Variable	AxB Interaction
Factual questions		X	
Understanding questions		X	
Application questions		X	X
Similarity topics		X	
Tangents and right triangles		X	
Coordinate geometry		X	
Total Test		X	

* X = $p < .05$ See Appendix G for more detail on these analyses

Table 7

F Tests for School 2*

	A Rote-Conceptual Variable	B Achievement Level Variable	AxB Interaction
Factual questions		X	
Understanding questions		X	
Application questions	X	X	
Similarity topics		X	
Tangents and right triangles	X	X	
Coordinate geometry			
Total Test		X	

* X = $p < .05$ See Appendix G for more detail on these analyses

Table 8

F Tests for School 3*

	A Rote-Conceptual Variable	B Achievement Level Variable	AxB Interaction
Factual questions		X	
Understanding questions		X	
Application questions		X	
Similarity topics		X	
Tangents and right triangles		X	
Coordinate geometry		X	X
Total Test		X	

* X = $p < .05$ See Appendix G for more detail on these analyses

Table 9

F Tests for All Schools Combined*

	A Rote-Conceptual Variable	B Achievement Level Variable	AxB Interaction
Factual questions		X	
Understanding questions		X	
Application questions		X	
Similarity topics		X	
Tangents and right triangles		X	
Coordinate geometry		X	
Total Test		X	

* X = $p < .05$ See Appendix G for more detail on these analyses

posttest scores must be accounted for by factors other than those represented by the score on a general aptitude test. Perhaps the discrepancy of scores on the aptitude and achievement tests is a reflection of motivational factors which influence geometry achievement but not general aptitude. It appears that whatever factors are operating here contribute to higher achievement not only through extra effort expended in out of class study time, but also through better study habits, attention factors or the like, since the different achievement groups received the same study time. It is also apparent from the data that the choice of program form should depend on the type of school in which the program is to be used, as well as the achievement characteristics of the student. Whichever form is chosen, there is small chance that it will vitiate differences between overachievers and underachievers.

GENERAL CONCLUSIONS

A number of somewhat speculative conclusions were reached by project members during the series of experiments conducted with the programed geometry materials. These conclusions are not, for the most part, based on direct experimental evidence; they are derived largely from informal observations of student behavior during the study. Nevertheless, they may be useful for suggesting lines of future research.

First, it appears that the appropriate and critical dimensions for specifying the learning task, the teaching method, and the student have not yet been identified. Consequently, there is not a sound basis for exploring relationships between task, method, and student variables as they determine the efficiency of student learning under programed instruction.

For example, "high anxiety" may not be a unitary dimension of student behavior or personality. Perhaps we need to specify the precise conditions under which the student exhibits symptoms of "anxiety." Likewise, "rote learning" and "conceptual learning" may be composites of many functional task variables that should be isolated and identified if we are to find systematic interactions among variables.

It appears that considerable effort should be devoted toward an analysis and classification of task, method, and student variables that yield systematic relationships under programed instruction. Such a classification system might well form the basis for a model of learning behavior.

A second, and related, conclusion is that formal experiments on programed instruction should be preceded by a period of informal hypothesis generation.

The aim of this preliminary stage should be to ensure that critical variables of practical importance are identified before time and effort are spent on rigorously controlled experimental comparisons that may yield no significant differences. The method used in this preliminary phase should be that of informal manipulation and observation, probably working with small groups of students and with simplified equipment. Highly significant variables should be noticeable even under such loosely controlled conditions; the effects of these variables can then be determined more precisely by formal experimentation.

A third conclusion is that the potential advantages of programed instruction, and particularly of highly responsive programed instruction, are not most effective at the secondary school level. Students at this level have already acquired fairly stable habits of study and reading. These habits appear to overshadow the effects of specific method of instruction.

Research currently planned for the primary school level should indicate whether children at this level will, as hypothesized, be more influenced by the mode of instruction, and hence better able to take advantage of responsive programed instruction.

One further general conclusion of the project is that attempts to keep the methods of instruction within the conventional definition of "automated teaching" or "programed instruction" have impaired the effectiveness of the instruction. A consequence of this artificial constraint is that the advantages that might have been gained through making the instruction more responsive to student differences were not fully realized.

As an example, it appears that children learning theorem proofs did not have a clear notion of the over-all organization of the proofs. They were, in many cases, not able to see the relationships of the various steps to each other, even in the conceptual materials. Such an understanding of relationships --of the contribution that each step makes toward the final solution--is essential for generalization and transfer of training.

In future research at System Development Corporation, an attempt will be made to determine the most effective combination of instructional techniques and methods for specified tasks and for students of specified characteristics. In some cases the use of organizing frames, presented independently of the detailed instructional items, may help the student to structure his task and to synthesize or integrate the steps toward its solution. Such an organizing frame might represent an over-all outline of the problem solution, with each step in the outline numbered. Individual instructional items in the programed sequence could contain corresponding numbers, so that the student could always determine where a particular item fits into the general solution.

Another approach to the teaching of synthesizing or integrative behavior might involve the combination of programed instruction and information retrieval techniques. Students might be allowed to request different categories of information during the instruction; one available category might consist of relational material reviewing earlier topics and previewing topics to be covered later in the lesson.

APPENDICES

APPENDIX A

DESCRIPTION OF SDC TEACHING MACHINE

The computer-based teaching machine consists of three elements: a Bendix G-15 computer, a large random-access slide projector, and an electric typewriter. The student sits in front of the typewriter and reads instructional items which are displayed by rear-view projection from 35-mm slides in the random-access projector. He then enters his multiple choice answer on the typewriter. Answers are recorded and evaluated in the computer. Feedback is supplied by a typewriter printout. The computer then determines which slide to present next. The computer then selects the next slide from the projector and the cycle is repeated.

The decision criteria governing slide selection are preprogramed by the person designing the lesson. The computer may be programed to select different slide sequences in response to a variety of student behavior. For example, if a student accumulates a prespecified number of errors on a set of diagnostic items he will be branched to specially designed remedial items. Or, if he takes too much time in responding to the items, he may be branched to extra items. Or, he may indicate by pressing a key that he is having trouble and wants to review certain topics. If the student makes no errors, responds rapidly, and feels confident, items will be skipped, permitting more rapid progress. A teaching machine with the sequence of instructional items tailored to the needs of the student is based on the notion that there is no single best item sequence. As research with this machine reveals dimensions of individual differences which interact with method and task variables, the machine can be programed to treat students differently with respect to such dimensions. This tracking of the student's performance is expected to make a substantial contribution to student learning.

APPENDIX B

TOPICS COVERED BY PROGRAMED BOOKLETS

	Topic	No. of Pages	Booklet*
1.	Ratio and proportion.	50	1R
2.	Three or more parallel lines cut off proportional segments on any two transversals.	44	2R
3.	Two triangles are similar if two angles of one equal respectively two angles of the other.	62	2R
4.	Two triangles are similar if an angle of one equals an angle of the other and the included sides are proportional.	28	3R
5.	If two chords intersect within a circle, the product of the segments of one chord is equal to the product of the segments of the other chord.	66	3R
6.	Review Topics 2-5.	116	4R
7.	If from a point outside a circle, a tangent and a secant are drawn, then the square of the tangent is equal to the product of the whole secant and its external segment.	71	5R
8.	If the altitude is drawn to the hypotenuse of a right triangle, then the two right triangles formed are similar to the original triangle and to each other.	48	5R
9.	In a right triangle, the sum of the squares of the legs is equal to the square of the hypotenuse.	98	6R
10.	Review of Topics 7, 8, and 9.	112	7R
11.	Introduction to Coordinate Geometry (A).	70	8R
12.	Introduction to Coordinate Geometry (B).	85	9R
13.	Review of Coordinate Geometry.	80	10R

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*R = Rote form, C = Conceptual form

	Topic	No. of Pages	Booklet*
14.	Ratio and proportion.	50	1C
15.	Three or more parallel lines cut off proportional segments on any two transversals.	40	2C
16.	Two triangles are similar if two angles of one equal respectively two angles of the other.	63	2C
17.	Two triangles are similar if an angle of one equals an angle of the other and the included sides are proportional.	27	3C
18.	If two chords intersect within a circle, the product of the segments of one chord is equal to the product of the segments of the other chord.	59	3C
19.	Review Topics 15-18.	120	4C
20.	If from a point outside a circle, a tangent and a secant are drawn, then the square of the tangent is equal to the product of the whole secant and its external segment.	71	5C
21.	If the altitude is drawn to the hypotenuse of a right triangle, then the two right triangles formed are similar to the original triangle and to each other.	40	5C
22.	In a right triangle, the sum of the squares of the legs is equal to the square of the hypotenuse.	94	6C
23.	Review Topics 20-22.	103	7C
24.	Introduction to Coordinate Geometry (A).	70	8C
25.	Introduction to Coordinate Geometry (B).	89	9C
26.	Review of Coordinate Geometry.	84	10C

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* R = Rote form, C = Conceptual form

APPENDIX C

CRITERION TEST MATERIAL

1. Instructions to judges who classified the test questions for the criterion test.
2. Questions constituting the criterion test for each level and topic.
3. Geometry Quiz Part 1 and 2.
4. Key.

INSTRUCTIONS TO JUDGES WHO CLASSIFIED THE TEST QUESTIONS FOR THE CRITERION TEST

1. Look over all test items for technical errors.
2. Classify each item into one of the following categories:
    - A. Rote regurgitation of facts or specific knowledge, e.g., recognition or recall of a proof or statement in a proof.
    - B. Comprehension items indicating that the student understands the essence of the proof or the meaning of the theorem. These items involve translations or interpretations of direct implications of the theorem or proof and are non-numerical.
    - C. Application items requiring that the theorem be used in solving new problems that are different from the original theorems. Numerical or non-numerical indirect implications of the theorems are being assessed here. These items differ from B in requiring more transfer because situations are less like those encountered in the theorems.

QUESTIONS CONSTITUTING THE CRITERION TEST FOR EACH LEVEL AND TOPIC*

	Theorem 1	Theorem 2	Theorem 3	Theorem 4	Theorem 5	Theorem 6	Theorem 7	Coordinate Geometry
Fact	1,2	3,4	5,6	7,8	9,10	11,12	13,14	15-18
Understanding	19,20	21,22	23,24	25,26	27,28	29,30	31,32	33-35 & 37
Application	36,38	39,40	41,42	43,44	45,46	47,48	49,50	51-54

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*Numbers in the table correspond to the numbered items in the test which follows.

GEOMETRY QUIZ - PART 1

1. In proving that lines are proportional one theorem used the fact that lines are:

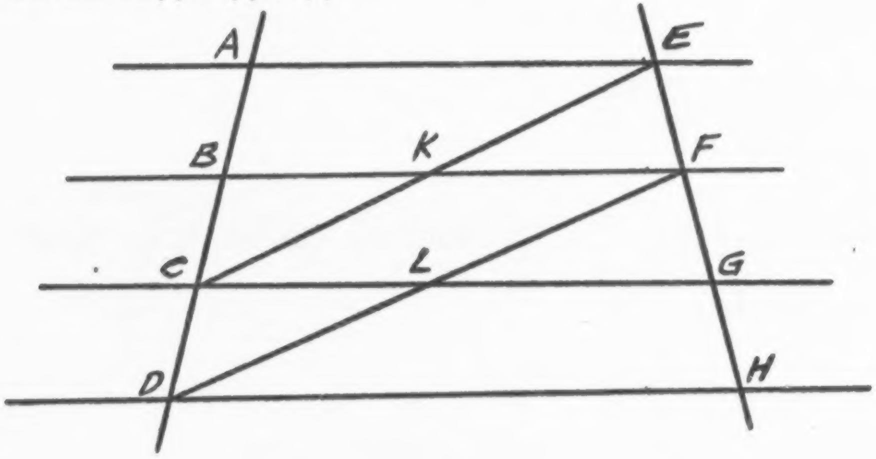
   (1) corresponding sides of equal angles

   (2) corresponding sides of congruent triangles

   (3) segments of two sides of a triangle made by a line parallel to the third side.

   (4) part of a proportion

2. Given AE//BF//CG//DH



The ratios $\frac{BC}{CD}$ and $\frac{FG}{GH}$ both equal _________.

(1) $\frac{FL}{LD}$

(2) $\frac{EK}{KC}$

(3) $\frac{CD}{GH}$

(4) $\frac{AB}{BC}$

3. In proving lines are parallel, one theorem used the fact that

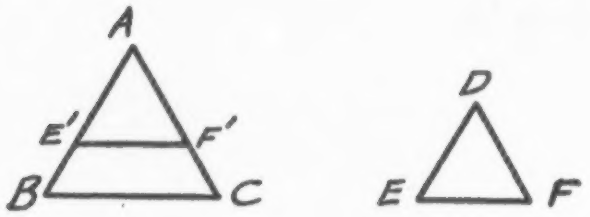
   (1) alternate interior angles were equal

   (2) they were perpendicular to the same line

   (3) they were opposite sides of a parallelogram

   (4) the corresponding angles were equal

4.



1. $\triangle AE'F' \cong \triangle DEF$

2. $\angle AE'F' = \angle B$

3. ---------------? What is the missing step?

4. $AB/AE' = AC/AF'$

(1) $\angle AE'F' = \angle E$

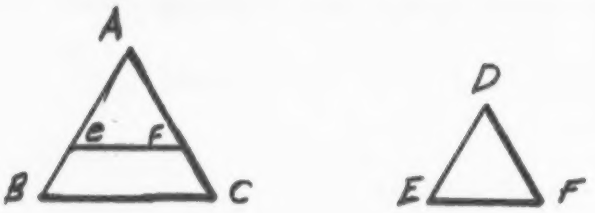
(2) $\frac{AB}{DE} = \frac{AC}{DF}$

(3) $\angle A = \angle D$

(4) $E'F' \parallel BC$

(5) $\triangle AE'F' \sim \triangle ABC$

5.



What are the following steps leading up to?

a) $\angle e = \angle B$, $\angle f = \angle C$ b) $\angle e = \angle E$, $\angle f = \angle F$

1. $\angle B = \angle E$, $\angle C = \angle F$
2. $\angle e = \angle f$, $\angle B = \angle C$
3. $\angle B = \angle e$, $\angle F = \angle f$
4. $\angle A = \angle D$, $\angle B = \angle E$

6. In proving the theorem "two triangles are similar if an angle of one triangle equals an angle of another and the including sides are proportional," a previously proven theorem was used which stated that two triangles are similar if __________ of one triangle equal respectively _____________ of the other.

1. three angles, three angles
2. an angle and the included sides, an angle and the included sides
3. two angles, two angles
4. three sides, three sides

7. In proving that two angles were equal one theorem used the fact that they

(1) were vertical angles

(2) were supplements of equal angles

(3) were alternate interior angles of parallel lines

(4) were base angles of an isosceles triangle

(5) were included angles

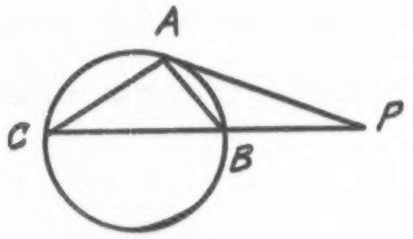
8. In proving that two products are equal one theorem used the fact that

(1) corresponding angles were equal

(2) a proportion could be made from the segments of intersecting chords

(3) corresponding parts of congruent triangles are equal

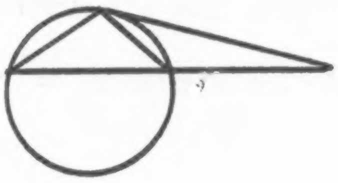
9.



We proved that $(AP)^2 = (CP)(BP)$ by first proving that ______________.

1. $\triangle CAB \sim \triangle BAP$
2. $\triangle CAP \sim \triangle CAB$
3. $\triangle BAP \cong \triangle CAP$
4. $\triangle BAP \sim \triangle CAP$

10.



Which of the following proportions was formed in the proof of the theorem involving tangents and secants?

(1) $$\frac{\text{tangent}}{\text{whole secant}} = \frac{\text{tangent}}{\text{external segment}}$$

(2) $$\frac{\text{tangent}}{\text{external segment}} = \frac{\text{tangent}}{\text{whole secant}}$$

(3) $$\frac{\text{external segment}}{\text{tangent}} = \frac{\text{whole secant}}{\text{tangent}}$$

(4) $$\frac{\text{external segment}}{\text{tangent}} = \frac{\text{tangent}}{\text{whole secant}}$$

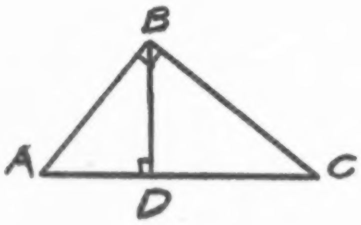
11. In a rt △ divided into similar △s by the altitude to the hypotenuse, it was proved that either leg is a mean proportional between two sides. In rt △ ABC, between what sides is AB a mean proportional?

(1) AD and DC

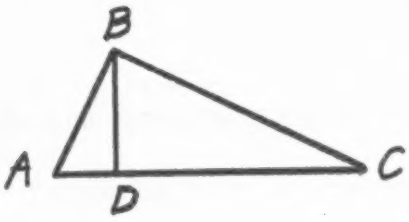
(2) DC and AC

(3) AC and AD

(4) BC and DC



12. Which of the following proportions represents the statement that the altitude is the mean proportional between the segments of the hypotenuse?



(1) $\frac{AC}{AB} = \frac{AB}{AD}$

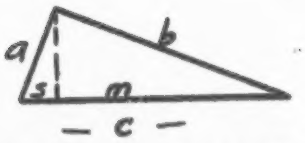
(2) $\frac{AD}{CD} = \frac{CD}{DB}$

(3) $\frac{AD}{BD} = \frac{BD}{DC}$

(4) $\frac{AC}{BC} = \frac{BC}{DC}$

(5) $\frac{AB}{BD} = \frac{BD}{BC}$

13.



To prove the Pythagorean theorem we first showed that a^2 = __________ and b^2 = __________.

1. cs, mb
2. ms, cs
3. mc, sm
4. sc, mc

14. Which of the following theorems was used in the proof of the Pythagorean theorem?

(1) Two △s are similar if 2 ∠s in one are equal, resp., to 2 ∠s in the other.

(2) Two △s are similar if an ∠ in one △ is equal to an ∠ in the other △, and the including sides are proportional.

(3) Two △s are similar if the sides in one △ are proportional to the sides in the other.

(4) The altitude to the hypotenuse in a rt △ divides the △ into △s similar to the original △ and to each other.

15. What theorem was used to obtain the distance formula?

(1) Three or more parallel lines cut off proportional segments on any two transversals.

(2) Two triangles are similar if two angles of one are equal respectively to two angles of the other.

(3) In a right triangle the square of the hypotenuse is equal to the sum of the squares of the two legs.

(4) If the altitude is drawn to the hypotenuse of a right triangle, then the two right triangles formed are similar to the original triangle and to each other.

16. In which quadrant are the values of x and y (-, +) respectively?

    (1) first

    (2) second

    (3) third

    (4) fourth

17. One of the principal differences between a line in Euclidian geometry and a line in analytic geometry is:

    (1) length

    (2) width

    (3) points

    (4) size

    (5) direction

18. Which of the following is the name for an x-coordinate?

    (1) abscess

    (2) ordinate

    (3) abscissa

    (4) cardinal

    (5) ordinal

19. "A line parallel to the base of an isosceles triangle cuts off another isosceles triangle." This statement is

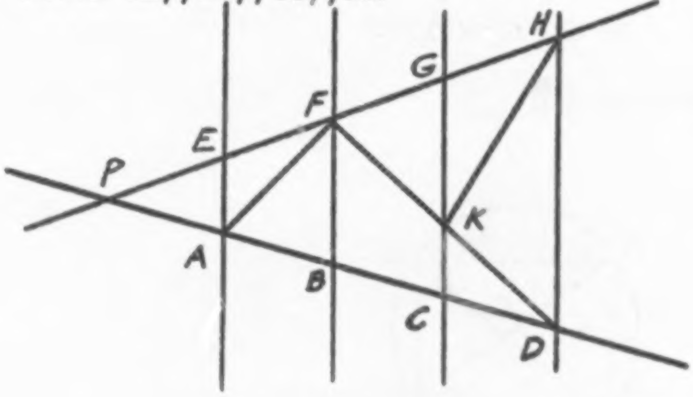
(1) always true

(2) sometimes true

(3) never true

(4) indeterminate

20. Given AE//BF//CG//DH



In the following proportion, what is the missing term (x)? $\frac{FG}{PH} = \frac{x}{PD}$

(1) EF

(2) AB

(3) BC

(4) CD

(5) FK

21. In general, what is the method of proof for the theorem "Two triangles are similar if two angles of one equal respectively two angles of the other?"

(1) Two angles of one triangle are proven equal respectively to two angles of the other.

(2) The triangles are proved similar by s.a.s

(3) The triangles are shown to be similar by s.s.s

(4) The triangles are shown to have corresponding sides proportional.

22. a) $\angle AED = \angle BEC$, b) $\angle DAC = \angle CBD$; c) $\triangle AED \sim \triangle BEC$

What are the three steps above leading to?

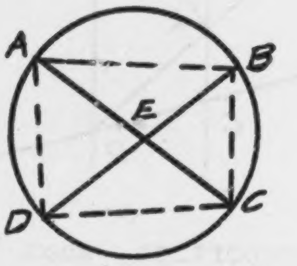
(1) $\triangle AED \sim \triangle BEC$

(2) $\angle ADE = \angle BCE$

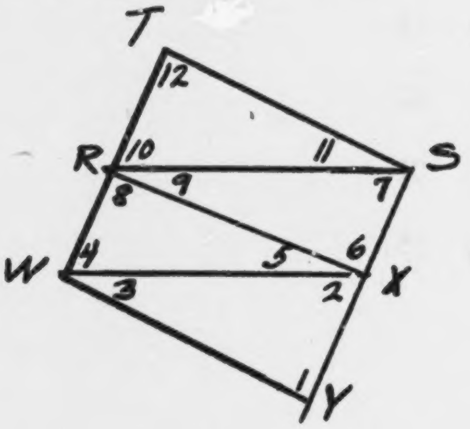
(3) $\triangle ABE \sim \triangle DEC$

(4) $\angle AEB = \angle DEC$

(5) $(AE)(EC) = (DE)(EB)$



23. In which of the following cases are two triangles similar?



(1) $\frac{TS}{RS} = \frac{RX}{WX}$; $\angle 1 = \angle 2$

(2) $\frac{RS}{RT} = \frac{WX}{WY}$; $\angle 10 = \angle 5$.

(3) $\frac{RT}{WY} = \frac{RS}{WX}$; $\angle 10 = \angle 3$

2

24. "Two iscsceles triangles are similar if their vertex angles are equal." This statement is

(1) always true

(2) sometimes true

(3) never true

(4) indeterminate

25. Given: chords AB and CD intersecting at E.

To prove: (AE)(EB) = (CE)(ED)

It is possible to prove this by drawing construction lines and showing that $\triangle AED \sim \triangle CEB$. Which of the following is another way of proving it?

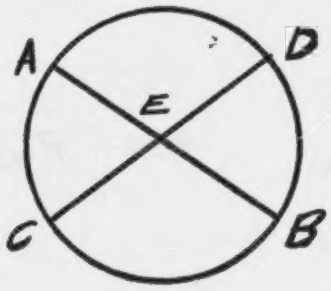
(1) Prove $\triangle AEC \sim \triangle EBD$

(2) Prove $\triangle ABD \sim \triangle EBD$

(3) Prove $\triangle ABC \sim \triangle EBC$

(4) Prove $\triangle ADB \sim \triangle ACB$

(5) Prove $\triangle AEC \sim \triangle AED$

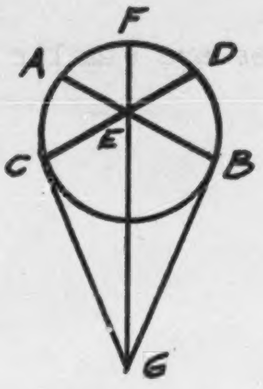


26. (A) $\frac{AE}{ED} = \frac{CE}{EB}$

(B) $\angle AEC = \angle DEB$

(C) $\angle BAC = \angle CDB$

(D) $\triangle ACE \sim \triangle BDE$



What is the correct sequence of the above statements?

(1) BCAD

(2) CBDA

(3) ABCD

(4) DBCA

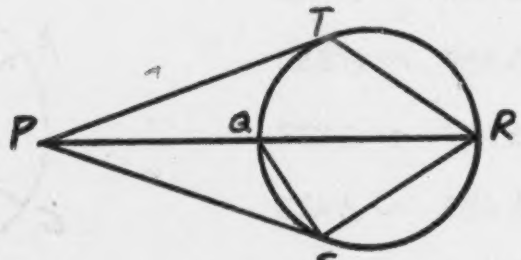
27. In the proof of the theorem involving the numerical relationship between a tangent and a secant, which triangles were proved similar?

(1) PQS and QRS

(2) PQS and PRS

(3) PRS and QRS

(4) PTR and PQS



28. If $\angle KLN = 35^\circ$, what other angle $= 35^\circ$?

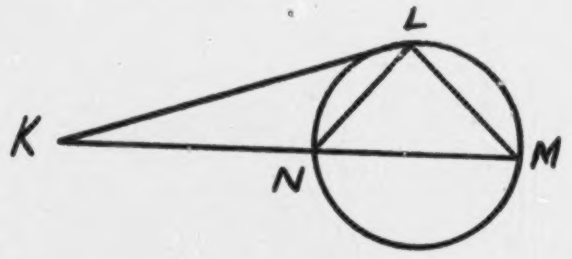
(1) $\angle KNL$

(2) $\angle KNM$

(3) $\angle KML$

(4) $\angle KLM$

(5) none of the above



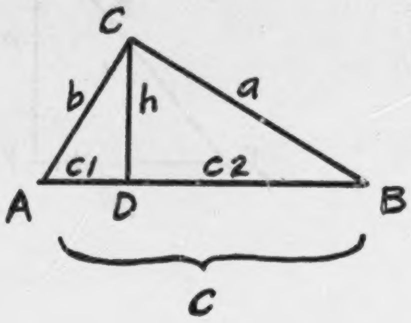
29. In the right triangle shown, the altitude h is perpendicular to the hypotenuse AB. Which of the following do not represent corresponding sides in the three triangles ABC, ACD and BCD respectively?

(1) b, C_1, C_2

(2) C, b, a

(3) b, C_1, h

(4) a, h, C_2



30. How were the triangles proved similar in the following theorem?

"If the altitude is drawn to the hypotenuse of a right triangle, then the two right triangles formed are similar to the original triangle and to each other."

(1) The triangles were proved to be right triangles.

(2) Two angles were proved equal respectively in each pair of triangles.

(3) Each pair of triangles were proved to have corresponding sides equal.

(4) The triangles were shown to have corresponding sides proportional.

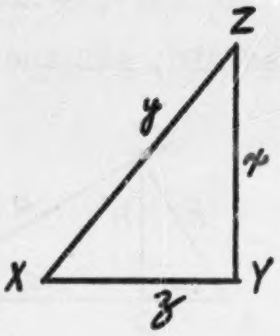
31. A student drew a figure of a right triangle, but did not label it correctly. Which side should be opposite the right angle?

(1) 60

(2) 80

(3) 100

32. In right triangle XYZ, if x and y are known, what would be the correct "formula" for finding z?



(1) $x^2 - y^2$

(2) $y^2 - x^2$

(3) $\sqrt{y^2 - x^2}$

(4) $\sqrt{x^2 - y^2}$

(5) $\sqrt{x^2 - y^2}$

33. What happens to the distance formula when it is applied to a line parallel to the x-axis?

(1) The term $(x_1 - x_2)^2 = 0$

(2) The term $(y_1 - y_2)^2 = 0$

(3) The expression becomes $\sqrt{x_1^2 - y_1^2}$

(4) Both y_1 and y_2 are zero

(5) It depends on the length of the line

34. If a line is parallel to the y axis, what coordinate is the same for every point on the line?

(1) x coordinate

(2) y coordinate

(3) neither

(4) indeterminate

35. Given: P_1: (a,b) and P_2: (r,s). What are the coordinates of the midpoint of $\overrightarrow{P_1P_2}$?

(1) (a+r, b+s)

(2) (a-r, b-s)

(3) $\left(\frac{a+r}{2}, \frac{b+s}{2}\right)$

(4) $\left(\frac{a-r}{2}, \frac{b-s}{2}\right)$

(5) $\left(\frac{r-a}{2}, \frac{s-a}{2}\right)$

36. If 4 parallel lines are cut by two transversals, and the segments of one transversal are: 1, 3, and 4, and the segment which is 1 on the first transversal is 5 on the second transversal, the other two segments on the second transversal are:

(1) 7 and 8

(2) 15 and 10

(3) 3 and 20

(4) 12 and 16

(5) 15 and 20

37. On a line going through the origin, which contains points P_1 and P_2, if $\overrightarrow{OP_1}$ is positive and $\overrightarrow{OP_2}$ is negative, what is $\overrightarrow{P_1P_2}$?

(1) +

(2) -

(3) either

(4) indeterminate

38. Given triangle ACF such that BD // CF, one could use any one of several proportions. Which of the following could NOT be used?

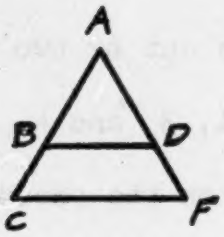
(1) AB/BC = AD/DF

(2) AC/BC = AF/DF

(3) AB/AD = BC/DF

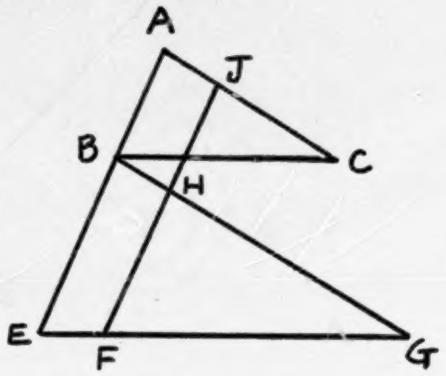
(4) AC/AF = AB/AD

(5) AB/AC = DF/AF



GEOMETRY QUIZ - PART 2

39. $\angle ACB = \angle BGE$, $AE \parallel FJ$ What may be concluded?



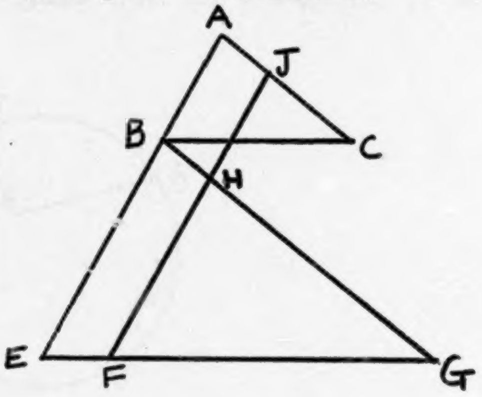
(1) $HF = AB$

(2) $\angle GHF = \angle GBE$

(3) $\triangle ABC \cong \triangle HFG$

(4) $\angle AJF = \angle GFJ$

40. $\angle A = \angle EBG$, $\triangle ABC \cong \triangle HFG$ What may be concluded?



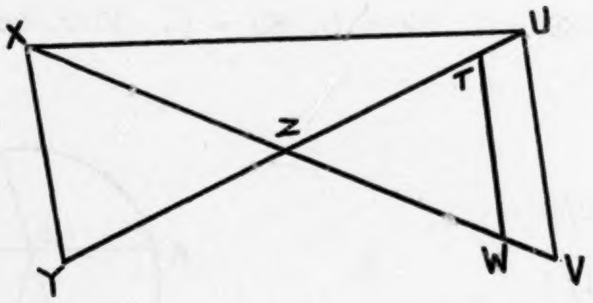
(1) $\triangle ABC \sim \triangle BEG$

(2) $HF \perp EG$

(3) $AB:HF = AC:HF$

(4) $\angle A = \angle E$

41. $XZ:ZV = YZ:ZU$ What may be concluded?



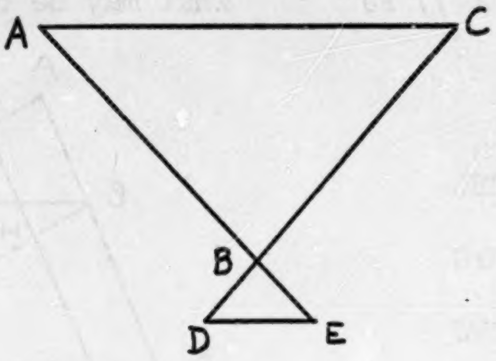
(1) $\triangle XYZ \cong \triangle ZUV$

(2) $\triangle XYZ \sim \triangle ZTW$

(3) $\triangle XYZ \sim \triangle ZUV$

(4) not enough information

42. In the figure, AC // DE. Which of the following is a pair of corresponding sides?



(1) BC and BE

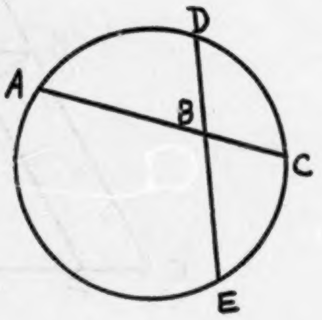
(2) BD and DE

(3) AB and BE

(4) BD and BE

(5) AB and BD

43. AC and DE are two chords of a circle intersecting at a point B. If AB = 4, DB = 3, and BE = 2, how long is BC?



(1) 1

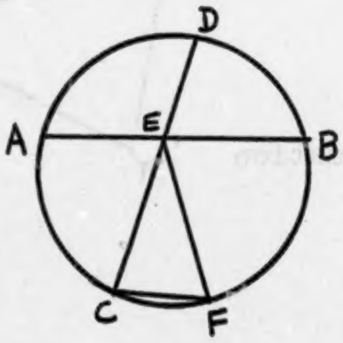
(2) 1 1/2

(3) 2

(4) 2 2/3

(5) 3

44. AE = 4, EB = 7, EF = 6, ED = 6. What is CE?



(1) 3

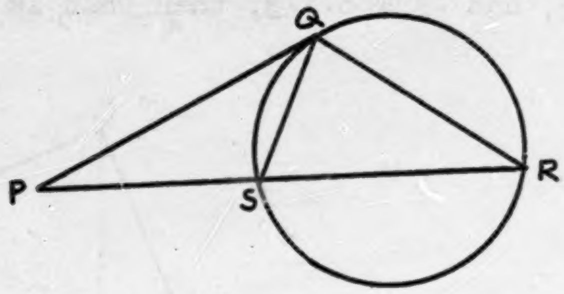
(2) 3 2/3

(3) 4 1/3

(4) 4 2/3

(5) 14

45. If $\angle R = \angle PQS + \angle P$, what can we conclude?



(1) $\triangle PQR \cong \triangle PQS$

(2) $\triangle PQS \sim \triangle PQR$

(3) $(PQ)^2 = (PR)(PS)$

(4) not enough information

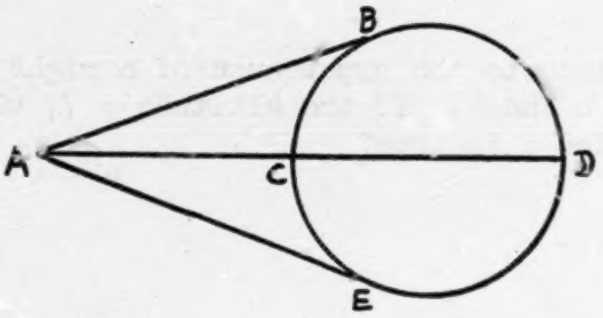
46. AE is a tangent

AB is a tangent

AD is a secant

AC = 4

AD = 9



What is AB?

(1) 13

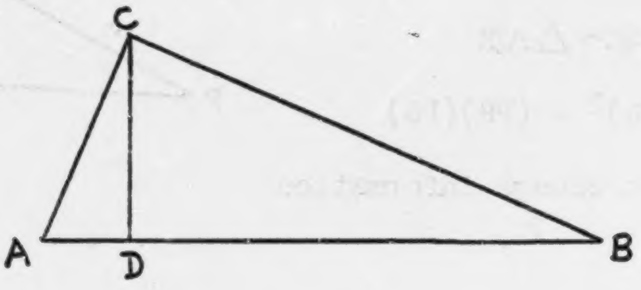
(2) 6 1/2

(3) 6

(4) 36

(5) not given

47. Right triangle ACB has an altitude CD. If AD = 3, and AB = 8 1/3, then what is AC?



(1) 16

(2) 5 1/3

(3) 4 2/3

(4) 4

(5) 5

48. The altitude to the hypotenuse of a right △ divides the hypotenuse into segments b and c. If the altitude = 7, which of the following statements about b and c is true?

(1) $bc = 7$

(2) $b = 4$, $c = 3$

(3) $bc = 49$

(4) $b:c = 1:\sqrt{7}$

(5) $\frac{b+c}{b} = 49$

49. What is the altitude of an equilateral triangle whose side is 10?

(1) $5\sqrt{3}$

(2) $5\sqrt{5}$

(3) 10

(4) $10\sqrt{2}$

(5) none of the above

50. A ladder 20' long leans against a wall. The bottom of the ladder is 12' from the foot of the wall. How far from the ground is the top of the ladder?

(1) 14'

(2) 15'

(3) 16'

(4) 17'

(5) 18'

51. Find the x-projection of $\overrightarrow{P_1 P_2}$ if $P_1 = (-5,4)$ and $P_2 = (8, 3)$.

(1) 3

(2) 7

(3) 1

(4) 13

52. $\overrightarrow{P_1 P_3} = 8$; $\overrightarrow{P_2 P_4} = 9$; $\overrightarrow{P_2 P_1} = -3$; $\overrightarrow{P_4 P_3} = ?$

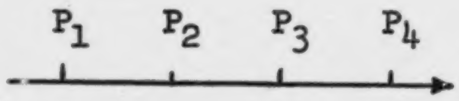
(1) 4

(2) 6

(3) -4

(4) -5

(5) -6



53. What is the distance from the x axis to (4, -3)?

(1) +3

(2) -3

(3) +4

(4) -4

54. What are the coordinates of P?

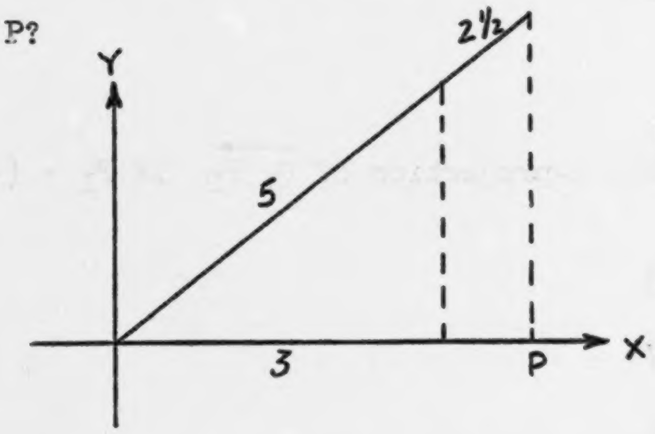
(1) (1 1/2, 0)

(2) (0, 1 1/2)

(3) (4 1/2, 0)

(4) (3 1/2, 4 1/2)

(5) indeterminate



GEOMETRY QUIZ ANSWER SHEET

For each question, mark an x in column 1-5 to indicate your choice.

	1	2	3	4	5
1.			/		
2.	/				
3.				/	
4.				/	
5.	/				
6.			/		
7.	/				
8.		/			
9.				/	
10.				/	
11.			/		
12.			/		
13.				/	
14.				/	
15.			/		
16.		/			
17.					/
18.			/		
19.	/				
20.			/		
21.				/	
22.					/
23.			/		
24.	/				
25.	/				
26.		/			
27.		/			

	1	2	3	4	5
28.			/		
29.	/				
30.		/			
31.			/		
32.			/		
33.		/			
34.	/				
35.			/		
36.					/
37.		/			
38.					/
39.		/			
40.	/				
41.			/		
42.			/		
43.		/			
44.				/	
45.				/	
46.			/		
47.					/
48.			/		
49.	/				
50.			/		
51.				/	
52.			/		
53.		/			
54.			/		

APPENDIX D

STUDENT CLASSIFICATION PROCEDURES

Two psychometric measures were used to determine the placement of students at the three achievement levels: the California Test of Mental Maturity ("aptitude") and the Seattle Geometry Test ("achievement"). Most students in the three participating schools had been tested with the aptitude measure within a year of the study, and the achievement test was administered at the end of the fall semester (January 1962).

Achievement tests were scored and converted to standard scores as prescribed in the test manual (Jeffery, H. B., et al). Standard scores for the aptitude test were obtained from school records. A total of 612 students had both scores available.

A program was written for the Philco 2000 computer to compute a least-square solution for the linear regression of achievement on aptitude (Guilford, 1954). Four separate calculations were made: for each of the three schools and for the total sample of students. Inspection of the data revealed that the three schools differed as to the calculated regression, so each school was treated individually in assigning students to achievement levels.

In most studies of under- and overachievement, students who exceed the achievement score predicted for them from the regression equation are treated as overachievers, while students who fail to reach the predicted scores are treated as underachievers. Such a method ignores the errors of measurement existing in both instruments. To take these errors of measurement into account, the standard error of estimate is used to establish a zone along the regression line, in which students may be classified as normal achievers. Typically, some fraction of the standard error of estimate is used (Burgess, 1956; Ahman, Smith and Glock, 1958); the justification for using a fraction of the standard error term is to create three groups of equal sizes. Such a method tends to cause most of the overachieving group to be drawn from the slower students and most of the underachieving group to be drawn from the brighter students (Duff and Siegel, 1960).

This problem can be overcome by using a full standard error of estimate to define the normal achieving group. By definition, 68% of the cases will fall in the normal zone, 16% will fall into the overachieving and 16% into the underachieving categories. To then create equal-sized groups, 16% of the cases lying closest to the regression line can be found. Using this method, the mean aptitude scores of the three groups will be essentially equal.

Table 10 has summary data from the computation of the regression of achievement on aptitude; Table 11 gives the number of cases at each of the three achievement levels for the three schools; and Table 12 contains a summary of the aptitudes for the three achievement levels and three schools.

Figures 1, 2 and 3 show the regression of achievement on aptitude for the three high schools.

Table 10

Summary Data from Computation of Regression of Achievement on Aptitude

School	N	Aptitude M	Aptitude SD	Achievement M	Achievement SD	Correlation (Apt-Ach)	Standard Error of Est.
1	223	113.52	11.74	107.61	10.93	.541	9.19
2	88	109.53	10.65	116.56	10.35	.444	9.27
3	301	112.47	11.92	115.95	10.38	.347	9.73

Table 11

Number of Cases at Each Achievement Level for the Three Schools

School	Over-achievers	Normal-achievers	Under-achievers
1	38	153	32
2	13	63	12
3	45	207	49

Table 12

Aptitudes for Three Achievement Levels at Three Schools

School	Over-achievers	Normal-achievers	Under-achievers
1	112.97	113.29	112.70
2	109.83	109.01	112.00
3	114.43	112.60	115.34

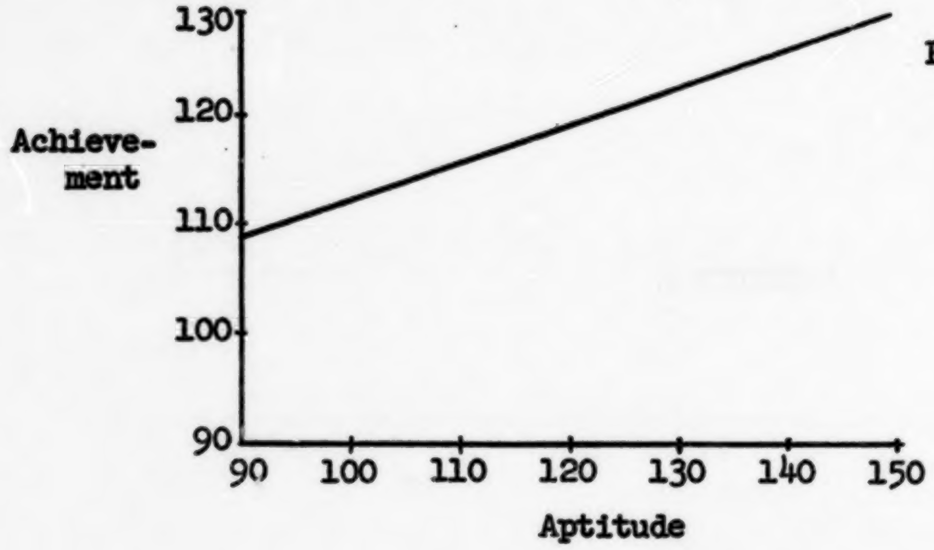


Figure 1. Regression of achievement on aptitude for School 3.

Ach = .3024 Apt + 81.9357

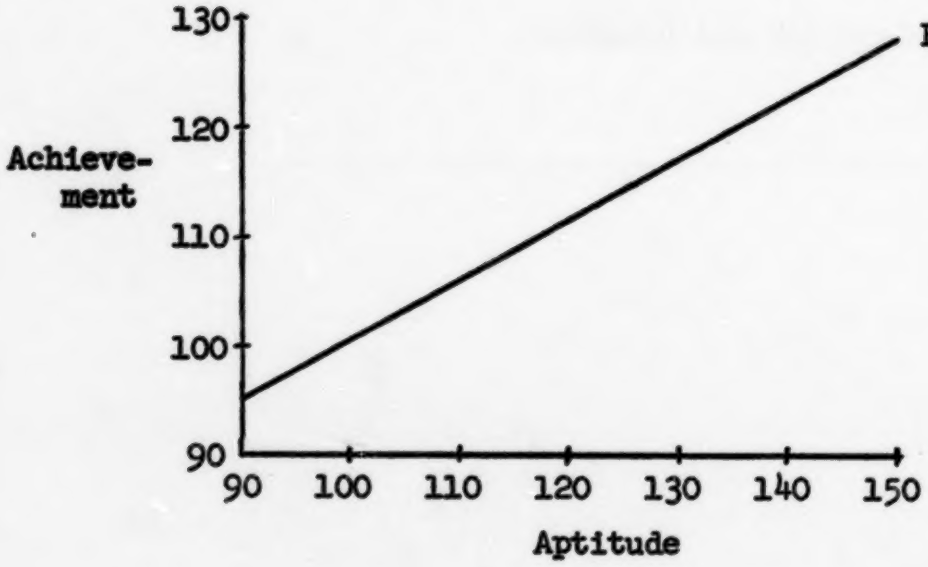


Figure 2. Regression of achievement on aptitude for School 1.

Ach = .5037 Apt + 50.4326

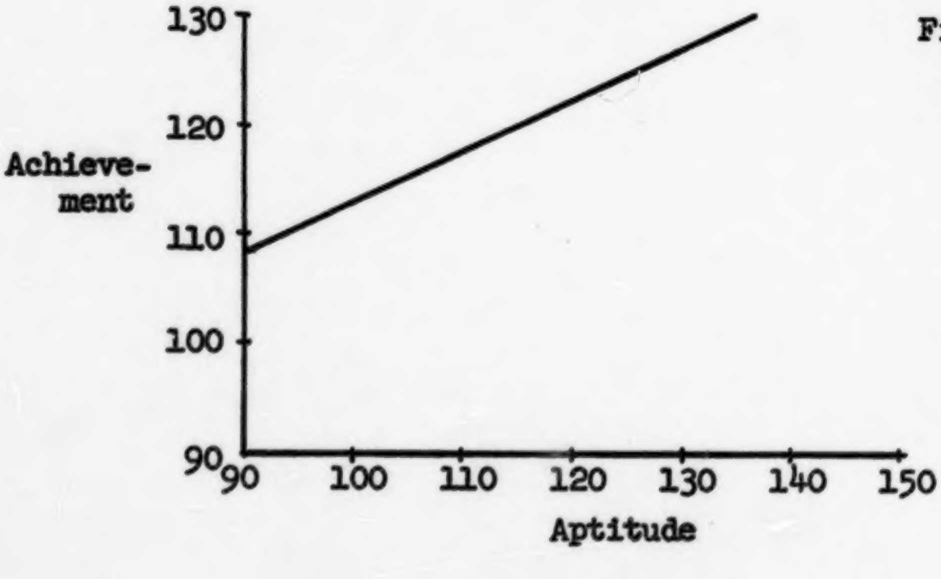


Figure 3. Regression of achievement on aptitude for School 2.

Ach = .4314 Apt + 69.3038

APPENDIX E

1. Instructions to Students

2. Teachers' Handbook and Schedule

INSTRUCTIONS TO STUDENTS

This workbook is designed to teach you geometry. You will discover that the workbook is different from any other book you have ever used.

On some of the pages, you will find multiple-choice questions, and on other pages, you will find text material. You are to read the material carefully and answer the questions. If you do work carefully, when you have completed the notebook you will have learned the topic being covered.

Here is how you use this workbook:

(1) Read all the text material very carefully. Study it as you would a textbook. If you are told to construct something on your scratch paper, do it. When you have studied a page sufficiently, turn to the next page.

(2) If a question is asked you, examine it completely and select an answer. Then, look on the back of the same page to find out what the correct answer to the question is.

(3) The questions are written so as to be very easy to answer. If you have studied the material well, you will have no difficulty answering the questions. If you make errors, then you will know that you have not been studying as you should.

(4) As you will see, the material is arranged so that you receive frequent questions, which allow you to determine how well you have learned the material. This is the reason for the use of questions: so that you will always know how well you are doing. There are no "trick" questions.

(5) Do not ask your teacher for assistance. All the help you need will be found in the workbook. If you are confused, you can look back to earlier pages, where you will always find the help you need.

(6) Make no marks in the workbook. When you answer a question, either write down your answer on your scratch paper, or keep it in your head until you turn the page for the correct answer.

(7) If you finish the workbook before the period has ended, go back and review it. Students who have used these workbooks have found it very beneficial to review the material when they complete a book.

(8) To repeat the main points:

- (a) read all text material carefully;
- (b) examine each question and select an answer;
- (c) check your answer with the correct one, on the back of the page;
- (d) do not ask your teacher for assistance;
- (e) do not mark in the book;
- (f) if you finish early, review the workbook.

Now turn to the first page, and begin. You should enjoy learning from this workbook.

TEACHERS' HANDBOOK AND SCHEDULE

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    b. student misses a day
    c. class misses a day
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    e. teacher misses a day

E. How to complete roll sheet 5

A. Overview of project

This project is sponsored by the United States Office of Education of the Department of Health, Education and Welfare in cooperation with the System Development Corporation, a nonprofit research organization located in Santa Monica.

The purpose of the project is to try out an improved workbook in plane geometry. The material contained in these workbooks has been prepared by geometry teachers from the Culver City, Lennox, and Santa Monica high schools. The content of the books cover the same topics that normally are taught in second semester plane geometry.

Students will be given the opportunity to complete the workbooks during the first few weeks in February. Workbooks of this type have been tried in other school districts and found to be very successful. Two forms of the workbook have been prepared. Some students have been assigned one form and other students have been assigned the other form. In order to obtain a fair comparison of the two forms, it is important that the students who have been assigned one form of the workbook not receive the other form during the three week trial period.

If you have any questions about the project, please feel free to call System Development Corporation (EXbrook 3-9411) and ask for Harry Silberman, Ralph Melaragno, or Evelyn Gunn.

SCHEDULE FOR THE PROJECT

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
Jan 29 Review	Jan 30 Review	Jan 31 Review	Feb 1 Workbook 000	Feb 2 Pre-Test
Feb 5 Pre-Test	Feb 6 Workbooks 001 and 011	Feb 7 Workbooks 002 and 012	Feb 8 Workbooks 003 and 013	Feb 9 Workbooks 004 and 014
Feb 12 HOLIDAY	Feb 13 Workbooks 005 and 015	Feb 14 Workbooks 006 and 016	Feb 15 Workbooks 007 and 017	Feb 16 Workbooks 008 and 018
Feb 19 Workbooks 009 and 019	Feb 20 Post-Test	Feb 21 Post-Test	Feb 22 HOLIDAY	Feb 23

B. What to cover during first week

Monday, Tuesday, Wednesday (Jan 29, 30, 31)

Review rooting, powering, subscripts, primes, powers. Also, review similarity vs. congruence. If you must use figures for the latter, use polygons other than triangles.

Thursday (February 1)

Review of ratio and proportion, with the special workbooks. If you feel it necessary (if any of the students are still unclear after using the workbooks), you may expand upon ratio and proportion. The workbooks should take about 1/2 hour for the students to complete, so you will have some time for your own review. (See "Instructions to students, before ratio and proportion workbook," Section C.)

Friday (February 2)

This entire period will be used for the first half of the pre-test. Follow your normal procedure for students who finish the test early.

C. Instructions to the Students

Before the ratio and proportion workbook (Thursday, February 1)

Tell the students that you have some workbooks you would like them to use. Pass out the workbooks, and have the students read the directions on the first page.

When they are finished reading the directions, say:

> "Go through the workbook at your own speed. Remember, make no marks in the workbooks, and don't ask me any questions. Start working now."

Some students will finish very quickly. Have them review the workbook. When all students have finished, collect the workbooks and have the students discuss them.

Before the first day of the study (February 6)

Remind the students of the ratio and proportion workbook they used last week. Tell them:

> "This week and next week we are going to use some more of these workbooks. You will use them in the same way you used the one last week."

Pass out the first workbooks and have the students read the directions inside the books. When they have finished, say:

> "Please don't make any marks in the workbooks. We'll want to use them again with other classes. Don't ask me any questions, unless you find a page missing, or there is a page which you can't read. Start working now, and I'll collect the workbooks at the end of the period."

D. Miscellaneous

1. Homework. There will be no homework assignments during the two-week period when the workbooks are being used.
2. Textbooks. The regular textbooks will be collected at the end of the first semester and will not be distributed until the project is completed.
3. How to fill period. The material is designed to fill the entire period. If any students finish the workbook before the period is over, they should review the workbook. This is mentioned in the instructions to the students.
4. Grades. The tests given at the conclusion of the two weeks with the workbook will count as equivalent to a regular two-week quiz.
5. Problems.
    a. Teacher's responses to student questions. If a page is missing in the student's workbook, the teacher will show him that page from his copy. For any questions concerning the content the

response should be essentially, "These workbooks were designed to be self-instructional. If you do not understand what you have read, re-read the material. If you still have a question, jot it down on your scratch paper. At the end of the two weeks use of these workbooks we can discuss, at length, any questions you have regarding the material."

b. Student misses a day. If a student misses a day, note this on the roll sheet. If convenient to provide a make-up period, do so, otherwise this student will drop one day behind the class.

c. Class misses a day. If an entire class misses a day, the schedule will slip one day for that particular class.

d. Student does not complete a workbook. If a student fails to complete a given workbook, he goes to the next book with the class. Note "I" for incomplete on the attendance sheet for any incomplete books. Tell the student, "The review section will adequately cover the material which you have missed."

e. Teacher misses a day. One of the teachers in the project will take over the class. The substitute will take the regular teacher's class (not geometry).

E. How to fill out the roll sheet

The roll sheets, which are provided, have already been filled out with the names and series numbers for students in your class. Series 001-009 means that student is to receive workbooks AR-3965/001/00 through AR-3965/009/00.

Series 011-019 means that student is to receive workbooks AR-3965/011/00 through AR-3965/019/00. The student must receive workbooks in numerical order, e.g., 011, 012, 013, ..., 019.

In the columns under the dates, indicate what the student did that day. During the first week (January 29-February 2) only indicate if the student was absent (with an "A").

During the main two weeks of the study, indicate which workbook the student had that day, and also indicate if the student failed to complete the workbook (with an "I"). If you have any comments to make, space is provided.

The sample below shows how the roll sheet should look.

NAME & SERIES		1/29	1/30	1/31	2/1	2/2	2/5	2/6	2/7	2/8	2/9
Kappler	001-009	A						001	002	003	004[3]
Nortman	011-019						A[1]	011I	012	013	014I
Ryans	011-019			A				011	A	012 013[2]	014

COMMENTS

[1] Missed class; made up pre-test after school.

[2] Did 012 in class, 013 after school.

[3] Asked for help.

A=absent I=incomplete

APPENDIX F

EVALUATION FORM

____
Print last name, first name

A = This workbook was excellent compared to the geometry textbook. I would like to have similar workbooks for all the material in the course.

B = This workbook was slightly better than the geometry textbook. I would like to have more of this kind of workbook and less time on the textbook during the course.

C = This workbook was about the same as the textbook. It doesn't matter whether we have the textbook or this kind of workbook for the rest of the course.

D = The textbook is slightly better than this workbook. I would like to have more time on the textbook and less of this kind of workbook during the course.

F = This workbook was very poor compared to the geometry textbook. I would like to have the textbook for all the material in the course.

Give your evaluation of the topics covered in the workbooks by printing one letter grade (A,B,C,D,F) in the blank space in front of each topic below using the definitions listed above. Feel free to use a plus sign (like C+) if you can't decide between two grades.

____ 1. Three or more parallel lines cut off proportional segments on any two transversals.

____ 2. Two triangles are similar if two angles of one equal respectively two angles of the other.

____ 3. Two triangles are similar if an angle of one equals an angle of the other and the included sides are proportional.

____ 4. If two chords intersect within a circle, the product of the segments of one chord is equal to the product of the segments of the other chord.

____ 5. If from a point outside a circle, a tangent and a secant are drawn, then the square of the tangent is equal to the product of the whole secant and its external segment.

___ 6. If the altitude is drawn to the hypotenuse of a right triangle, then the two right triangles formed are similar to the original triangle and to each other.

___ 7. In a right triangle, the sum of the squares of the legs is equal to the square of the hypotenuse.

___ 8. Introduction to coordinate geometry.

APPENDIX G

Data on analyses summarized in Tables 6-9

Table 11

Factual Portion of the Criterion Test for School 1

			Method	
			Rote	Conceptual
Achievement	Over	Mean	12.64	12.81
		Sigma	2.48	2.76
	Normal	Mean	10.23	10.86
		Sigma	2.88	2.67
	Under	Mean	9.68	10.45
		Sigma	2.94	2.62

Source	df	ms	F	p
Achievement	2	45.186	6.743	<.01
Method	1	7.229	1.078	-
A x M	2	.124	.018	-
Residual	124	6.701		
Total	129			

Table 12

Understanding Portion of the Criterion Test for School 1

			Method	
			Rote	Conceptual
Achievement	Over	Mean	11.59	11.14
		Sigma	3.38	2.55
	Normal	Mean	8.45	9.77
		Sigma	3.07	3.53
	Under	Mean	8.45	8.41
		Sigma	2.35	2.61

Source	df	ms	F	p
Achievement	2	54.080	7.713	<.001
Method	1	1.308	.186	-
A x M	2			
Residual	124	5.707	.814	-
Total	129	7.011		

Table 13

Transfer Portion of the Criterion Test for School 1

			Method	
			Rote	Conceptual
Achievement	Over	Mean	12.41	12.00
		Sigma	3.16	3.32
	Normal	Mean	8.27	7.91
		Sigma	2.91	2.92
	Under	Mean	8.59	8.41
		Sigma	1.87	2.74

Source	df	ms	F	p
Achievement	2	126.753	19.248	<.001
Method	1	5.206	.790	-
A x M	2	.902	.136	-
Residual	124	6.585		
Total	129			

Table 14

Similarities Portion of the Criterion Test for School 1

			Method	
			Rote	Conceptual
Achievement	Over	Mean	17.05	16.73
		Sigma	3.04	2.68
	Normal	Mean	14.23	13.23
		Sigma	3.32	3.32
	Under	Mean	13.55	13.36
		Sigma	2.68	3.04

Source	df	ms	F	p
Achievement	2	87.730	11.609	<.001
Method	1	10.835	1.433	-
A x M	2	4.554	.602	-
Residual	124	7.557		
Total	129			

Table 15

Tangency and Right Triangle Portion of the Criterion Test for School 1

			Method	
			Rote	Conceptual
Achievement	Over	Mean	11.27	11.68
		Sigma	3.77	3.83
	Normal	Mean	7.50	8.32
		Sigma	3.09	3.43
	Under	Mean	7.68	7.41
		Sigma	3.40	3.04

Source	df	ms	F	p
Achievement	2	120.000	12.050	<.001
Method	1	1.921	.192	-
A x M	2	4.791	.481	-
Residual	124	9.958		
Total	129			

Table 16

Coordinate Geometry Portion of the Criterion Test for School 1

			Method	
			Rote	Conceptual
Achievement	Over	Mean	8.77	7.55
		Sigma	2.71	1.97
	Normal	Mean	5.23	6.55
		Sigma	2.00	2.29
	Under	Mean	5.50	6.50
		Sigma	1.83	1.92

Source	df	ms	F	p
Achievement	2	35.014	8.619	<.001
Method	1	3.101	.763	-
A x M	2	14.307	3.522	<.05
Residual	124	4.062		
Total	129			

Table 17

Total Criterion Test for School 1

			Method	
			Rote	Conceptual
Achievement	Over	Mean	36.64	35.95
		Sigma	7.91	7.38
	Normal	Mean	26.95	28.09
		Sigma	7.30	7.54
	Under	Mean	26.73	27.27
		Sigma	5.96	5.96

Source	df	ms	F	p
Achievement	2	633.522	17.288	<.001
Method	1	.495	.013	-
A x M	2	.452	.012	-
Residual	124	36.645		
Total	129			

Table 18

Factual Portion of the Criterion Test for School 2

			Method	
			Rote	Conceptual
Achievement	Over	Mean	11.20	10.93
		Sigma	1.90	2.62
	Normal	Mean	10.00	10.00
		Sigma	2.66	2.50
	Under	Mean	9.07	8.13
		Sigma	2.91	2.75

Source	df	ms	F	p
Achievement	2	28.721	5.394	<.01
Method	1	6.863	1.289	-
A x M	2	3.578	.672	-
Residual	82	5.324		
Total	87			

Table 19

Understanding Portion of the Criterion Test for School 2

			Method	
			Rote	Conceptual
Achievement	Over	Mean	9.87	10.47
		Sigma	2.19	2.78
	Normal	Mean	8.73	8.33
		Sigma	3.15	1.89
	Under	Mean	6.73	7.00
		Sigma	1.77	2.66

Source	df	ms	F	p
Achievement	2	53.210	9.348	<.001
Method	1	.018	.003	-
A x M	2	4.915	.863	-
Residual	82	5.692		
Total	87			

Table 20

Transfer Portion of the Criterion Test for School 2

			Method	
			Rote	Conceptual
Achievement	Over	Mean	9.60	10.93
		Sigma	3.95	1.95
	Normal	Mean	9.20	7.67
		Sigma	3.62	2.55
	Under	Mean	6.27	6.80
		Sigma	2.27	3.10

Source	df	ms	F	p
Achievement	2	55.947	7.863	<.001
Method	1	1.013	.142	-
A x M	2	29.720	4.177	<.05
Residual	82	7.115		
Total	87			

Table 21

Similarities Portion of the Criterion Test for School 2

			Method	
			Rote	Conceptual
Achievement	Over	Mean	14.07	14.60
		Sigma	2.69	2.70
	Normal	Mean	13.67	12.07
		Sigma	3.68	1.15
	Under	Mean	10.67	10.47
		Sigma	3.50	3.40

Source	df	ms	F	p
Achievement	2	60.109	8.282	<.001
Method	1	12.179	1.678	-
A x M	2	19.658	2.708	-
Residual	82	7.257		
Total	87			

Table 22

Tangency and Right Triangle Portion of the Criterion Test for School 2

			Method	
			Rote	Conceptual
Achievement	Over	Mean	9.53	10.47
		Sigma	3.61	3.07
	Normal	Mean	8.33	7.93
		Sigma	3.36	2.84
	Under	Mean	6.07	5.87
		Sigma	2.14	2.25

Source	df	ms	F	p
Achievement	2	77.743	10.490	<.001
Method	1	.396	.053	-
A x M	2	12.093	1.631	-
Residual	82	7.411		
Total	87			

Table 23

Coordinate Geometry Portion of the Criterion Test for School 2

			Method	
			Rote	Conceptual
Achievement	Over	Mean	7.07	7.27
		Sigma	2.05	1.81
	Normal	Mean	5.93	5.93
		Sigma	2.35	1.61
	Under	Mean	5.33	5.47
		Sigma	1.54	1.89

Source	df	ms	F	p
Achievement	2	16.220	5.083	< .01
Method	1	.001	-	-
A x M	2	1.270	.397	-
Residual	82	3.191		
Total	87			

Table 24

Total Criterion Test for School 2

			Method	
			Rote	Conceptual
Achievement	Over	Mean	30.67	32.33
		Sigma	6.73	5.99
	Normal	Mean	27.93	25.93
		Sigma	8.64	4.64
	Under	Mean	22.07	21.93
		Sigma	5.92	6.31

Source	df	ms	F	p
Achievement	2	404.852	13.659	<.001
Method	1	14.948	.504	-
A x M	2	79.170	2.671	-
Residual	82	29.639		
Total	87			

Table 25

Factual Portion of the Criterion Test for School 3

			Method	
			Rote	Conceptual
Achievement	Over	Mean	12.50	12.50
		Sigma	2.50	1.71
	Normal	Mean	12.33	11.00
		Sigma	2.05	2.16
	Under	Mean	9.50	10.00
		Sigma	2.87	1.29

Source	df	ms	F	p
Achievement	2	28.901	6.528	<.01
Method	1	.199	.044	-
A x M	2	4.481	1.012	-
Residual	28	4.427		
Total	33			

Table 26

Understanding Portion of the Criterion Test for School 3

			Method	
			Rote	Conceptual
Achievement	Over	Mean	12.17	12.00
		Sigma	2.11	1.53
	Normal	Mean	10.83	8.33
		Sigma	2.97	1.37
	Under	Mean	7.50	7.67
		Sigma	2.36	1.25

Source	df	ms	F	p
Achievement	2	28.909	6.139	<.01
Method	1	9.004	1.912	-
A x M	2	7.885	1.674	-
Residual	28	4.709		
Total	33			

Table 27

Transfer Portion of the Criterion Test for School 3

			Method	
			Rote	Conceptual
Achievement	Over	Mean	14.67	12.67
		Sigma	2.62	2.69
	Normal	Mean	11.33	9.17
		Sigma	4.15	2.54
	Under	Mean	9.00	7.33
		Sigma	2.16	2.43

Source	df	ms	F	p
Achievement	2	43.391	5.614	<.01
Method	1	39.302	5.085	<.05
A x M	2	5.031	.651	-
Residual	28	7.728		
Total	33			

Table 28

Similarities Portion of the Criterion Test for School 3

			Method	
			Rote	Conceptual
Achievement	Over	Mean	18.00	18.00
		Sigma	2.16	1.63
	Normal	Mean	15.67	14.67
		Sigma	4.15	2.92
	Under	Mean	13.33	13.00
		Sigma	2.21	1.83

Source	df	ms	F	p
Achievement	2	43.068	6.907	< .01
Method	1	1.519	.243	-
A x M	2	2.370	.380	-
Residual	28	6.235		
Total	33			

Table 29

Tangency and Right Triangle Portion of the Criterion Test for School 3

			Method	
			Rote	Conceptual
Achievement	Over	Mean	13.83	11.00
		Sigma	3.93	2.58
	Normal	Mean	11.00	6.83
		Sigma	3.70	1.57
	Under	Mean	7.50	5.67
		Sigma	2.75	1.97

Source	df	ms	F	p
Achievement	2	62.502	6.671	<.01
Method	1	71.427	7.624	<.01
A x M	2	7.375	.787	-
Residual	28	9.368		
Total	33			

Table 30

Coordinate Geometry Portion of the Criterion Test for School 3

			Method	
			Rote	Conceptual
Achievement	Over	Mean	7.50	8.17
		Sigma	1.98	1.07
	Normal	Mean	7.83	7.00
		Sigma	1.34	1.91
	Under	Mean	5.17	6.33
		Sigma	2.41	1.60

Source	df	ms	F	p
Achievement	2	8.900	2.343	-
Method	1	.740	.194	-
A x M	2	4.091	1.077	-
Residual	28	3.798		
Total	33			

Table 31

Total Criterion Test for School 3

			Method	
			Rote	Conceptual
Achievement	Over	Mean	39.33	37.17
		Sigma	6.10	4.78
	Normal	Mean	34.50	28.50
		Sigma	8.56	3.99
	Under	Mean	26.00	25.00
		Sigma	6.53	3.92

Source	df	ms	F	p
Achievement	2	290.941	8.603	<.001
Method	1	77.856	2.302	-
A x M	2	38.743	1.145	-
Residual	28	33.815		
Total	33			

Table 32

Factual Portion of the Criterion Test for All Schools

			Method	
			Rote	Conceptual
Achievement	Over	Mean	12.12	12.12
		Sigma	2.39	2.73
	Normal	Mean	10.44	10.58
		Sigma	2.81	2.58
	Under	Mean	9.44	9.58
		Sigma	2.94	2.75

Source	df	ms	F	p
Achievement	2	86.415	13.987	<.001
Method	1	.015	.002	-
A x M	2	.492	.079	-
Residual	250	6.178		
Total	255			

Table 33

Understanding Portion of the Criterion Test for All Schools

			Method	
			Rote	Conceptual
Achievement	Over	Mean	11.07	11.02
		Sigma	2.99	2.57
	Normal	Mean	8.88	9.07
		Sigma	3.19	2.90
	Under	Mean	7.72	7.81
		Sigma	2.31	2.56

Source	df	ms	F	p
Achievement	2	131.891	20.483	<.001
Method	1	.287	.044	-
A x M	2	.200	.031	-
Residual	250	6.439		
Total	255			

Table 34

Transfer Portion of the Criterion Test for All Schools

			Method	
			Rote	Conceptual
Achievement	Over	Mean	11.74	11.72
		Sigma	3.81	2.89
	Normal	Mean	9.02	8.00
		Sigma	3.51	2.79
	Under	Mean	7.84	7.70
		Sigma	2.47	2.93

Source	df	ms	F	p
Achievement	2	199.463	26.958	<.001
Method	1	22.661	3.062	-
A x M	2	13.875	1.875	-
Residual	250	7.399		
Total	255			

Table 35

Similarities Portion of the Criterion Test for All Schools

			Method	
			Rote	Conceptual
Achievement	Over	Mean	16.14	16.16
		Sigma	3.21	2.84
	Normal	Mean	14.23	13.02
		Sigma	3.63	2.98
	Under	Mean	12.51	12.30
		Sigma	3.23	3.32

Source	df	ms	F	p
Achievement	2	158.497	19.667	<.001
Method	1	27.913	3.463	-
A x M	2	18.248	2.264	-
Residual	250	8.059		
Total	255			

Table 36

Tangency and Right Triangle Portion of the Criterion Test for All Schools

			Method	
			Rote	Conceptual
Achievement	Over	Mean	11.02	11.16
		Sigma	3.99	3.47
	Normal	Mean	8.28	7.98
		Sigma	3.57	3.07
	Under	Mean	7.09	6.63
		Sigma	3.03	2.77

Source	df	ms	F	p
Achievement	2	253.347	27.371	<.001
Method	1	7.821	.844	-
A x M	2	6.037	.652	-
Residual	250	9.256		
Total	255			

Table 37

Coordinate Geometry Portion of the Criterion Test for All Schools

			Method	
			Rote	Conceptual
Achievement	Over	Mean	8.00	7.53
		Sigma	2.53	1.83
	Normal	Mean	5.84	6.40
		Sigma	2.23	2.06
	Under	Mean	5.40	6.12
		Sigma	1.81	1.93

Source	df	ms	F	p
Achievement	2	50.024	13.265	<.001
Method	1	1.698	.450	-
A x M	2	6.337	1.680	-
Residual	250	3.771		
Total	255			

Table 38

Total Criterion Test for All Schools

			Method	
			Rote	Conceptual
Achievement	Over	Mean	34.93	34.86
		Sigma	7.97	6.87
	Normal	Mean	28.35	27.40
		Sigma	8.36	6.32
	Under	Mean	25.00	25.09
		Sigma	6.40	6.33

Source	df	ms	F	p
Achievement	2	1210.653	33.378	<.001
Method	1	36.552	1.007	-
A x M	2	30.791	.848	-
Residual	250	36.270		
Total	255			

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